Cambial activity in certain horticultural plants*

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As stated by the writer in a previous publication,† there is a scarcity of data respecting the season of cambial activity in woody plants. This lack of knowledge, particularly with respect to cambial activity in the fruit trees, is the more surprising when one considers its significance to pruning and fertilizer practices, and since ultimately a rational system of fruit culture will be based on an accurate knowledge of the life history of the plant. It was in the hope of supplying some of the desired information that an investigation on this subject was begun in the summer of 1909.‡ It was found impossible to continue the investigation, except for a few observations made in the summer of 1913, but because of the scarcity of data on this subject it seems advisable to record the results of the observations made.

OBSERVATIONS ON THE GRAPE

Methods.—For the investigation a number of vines were selected of the Worden variety (*Vitis labrusca*). They were uniform as regards size and conditions of growth. They had been growing for four years on a plot of land on the campus of Cornell University, Ithaca, New York. The vines were under the care of the Department of Pomology, and had been properly pruned during the previous seasons.

At intervals throughout the season cuttings were taken from the one-year-old wood. These cuttings were removed in all cases from the basal internodes of different shoots and, as far as possible, from shoots of the same exposure and the same diameter. Cuttings from new shoots were likewise made from the basal

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† Observations on the inception, season, and duration of cambium development in the American larch [*Larix laricina* (Du Roi) Koch]. Bull. Torrey Club **40**: 271–293. *pl. 18, 19.* 1913.

‡ The field notes and collection of material were made by Dr. George R. Hill, Jr.

internodes. The material was fixed in Gilson's solution, imbedded in celloidin, and later sectioned and stained. On the same days that material was collected, observations were taken on the external manifestations of growth in order that the formation of xylem and phloem could be correlated with the growth of leaves, elongation of new shoot, and development of fruit.

In TABLE I are given the data on the growth-measurements in the grape.

TABLE I

DIAMETER INCREASE OF PHLOEM AND XYLEM IN ONE-YEAR-OLD SHOOTS OF THE GRAPE

Number of cutting	Date	Diameter of branch, mm.	Increase of xylem, microns	Increase of phloem, microns	Leaf, fruit, and shoot development
4	May 8	3.5	0	0	Buds swelling
12	" 15	4.75	0	0	Largest leaf 2 mm. wide
25	" 23	6	0	0	New shoot 30 cm. long. Largest leaf 11 mm. wide. Fruit-bud cluster 3 cm. long
46	" 29	4.5	102	61	Leaf 16×16 cm. New shoot 60 cm. long. Fruit-bud cluster 6–8 cm. long, not yet open
74	June 7	4.75	0	0	Largest leaves 18×18 cm. New shoot 86 cm. Fruit-bud cluster 5.5 cm. long; some open
94	" 15	5	143	73	Leaf 20×19 cm. New shoot 96 cm. Tendril developing. Axillary shoot 12 cm. long, with leaves 4 cm. broad. Fruit set. Only occasional stamens to be seen
110	" 20	—	102	71	Leaf 20 cm. broad. New shoot 100 cm. Grapes size of peas
144	" 29	6.5	486	222	Leaf 20×20 cm. New shoot 155 cm. Size of berries (largest) 12 mm. diameter
168	July 19		1,000	445	New shoot 195 cm.
185	Aug. 9		980	405	Grapes nearly full-grown, 16 mm. diameter
197	Nov. —		729	405	

Diameter increase began simultaneously in both phloem and xylem. The cambial activity began between May 23 and May 29, at which time the leaves were almost completely developed. Cambial activity ceased before August 9, for at this time the new xylem and the new phloem were completely differentiated and the cambium was in the resting condition. Between July 19 and August 19 a periderm layer was produced, cutting off the old phloem from the new. At the base of the new shoot, at about the same time, a periderm layer developed just outside the phloem, cutting off the entire cortex.

OBSERVATIONS ON THE PEACH

In studying cambial activity in the peach the methods employed were essentially the same as for the grape. Three peach trees were used, all growing under apparently identical conditions on the grounds of Cornell University. The trees were of the variety known as Wakefield and they were probably fifteen years of age. They had produced a good crop of fruit during the preceding season, and the same held true for the year when the observations were made. Cuttings were taken of one-year-old, five-year-old, and ten-year-old branches, the branches being respectively of approximately the same exposure and the same diameter. The detailed data follow in TABLE II.

TABLE II

AVERAGE DIAMETER INCREASE IN THE PEACH

Date of cutting	One-year-old branches		Five-year-old branches		Ten-year-old branches		General notes on growth
	Xylem microns	Phloem microns	Xylem microns	Phloem microns	Xylem microns	Phloem microns	
May 8..	61.5	—	112	92.2	287	102	Buds just opening
" 15..	61.5	49	153	82	184	102	Leaves 4 cm. long. Late blooming period
" 23..	143	114	143	120	205	102	Leaves 9 cm. long. New shoots 2 or 3 cm. in length
" 29..	—	—	225	123	307	123	Leaves 9 cm. long, full-grown. New shoot 6 cm. Fruit 20×10×12 mm.
June 7..	174	94	225	120	410	266	New shoot 9 cm. long. Fruit 22×25×33 mm.
" 1 ..	—	—	246	164	512	307	New buds evident. Fruit 27×30×36 mm.
" 20..	266	116	205	153	584	320	Fruit 38×30×28 mm. Stone just hardened
" 29..	95	69	250	205	500	287	Fruit 40×35×30 mm.
July 19..	166	75	205	164	492	307	Fruit just beginning to ripen
Aug. 9..	145.9	75	266	164	389	205	

An examination of the table reveals the fact that cambial activity began in the peach at the time of the opening of the buds. This is contrary to the condition found in the larch, grape, and apple. Complete differentiation of the new xylem was evident by July 19, when the cambium layer appeared to be in a resting condition. It is not possible to draw conclusions regarding the period of greatest cambial activity, since the variation in growth in the different branches is apparently considerable.

OBSERVATIONS ON THE APPLE

The methods of investigation in the apple were essentially the same as in grape and peach. Only one tree was used. It was growing on the campus at the foot of a four-foot road embankment The tree was about forty years old, and for several years no practical attention had been given it. Cuttings were removed from one-year-old branches, from four-year-old branches and from one of the main branches having a diameter of 4 cm. The detailed data are given in TABLE III.

TABLE III

AVERAGE DIAMETER INCREASE IN THE APPLE

Date of cutting	One-year-old branches		Four-year-old branches		Ten-year old branches		General notes
	Xylem microns	Phloem microns	Xylem microns	Phloem microns	Xylem microns	Phloem microns	
May 8..	32	0	—	—	0	0	Leaves 2.5×1.5 cm. Pink of fruit buds evident.
" 15..	40	0	20	—	123	—	Leaves 2.5×2 cm. Full bloom
" 23..	40	40	100	—	—	—	Leaves 6.5×3 cm. Fruit set
" 29..	150	82	157	133	205	—	Leaves 11×4 cm. Full-grown. Fruit 8 mm. diameter
June 15..	287	98	180	123	246	143	Fruit 18 mm. diameter
" 20..	430	143	246	205	512	185	Fruit 23 mm. diameter
" 29..	686	123	440	125	540	164	New buds appearing. Fruit 36 mm. diameter
July 19..	—	—	594	246	492	164	Fruit 37 mm. diameter
Aug. 9..	379	82	840	205	738	160	
Nov. 4..	594	90.2					

In each case cambial activity began before May 15, but it was impossible to determine from the sections whether or not phloem formation had begun. In all cases xylem formation was completed by July 19 and the characteristic thickening of the cell walls was also practically completed. By August 9, the date of the last observations, the cambium was in its resting condition. The most rapid increase began just after the leaves had attained full size.

INCIDENTAL OBSERVATIONS IN 1913

Material for examination was collected in 1913 from the apple, peach, pear, plum, and cherry. Two apple trees were examined, a Baldwin and a Rhode Island Greening. The trees were about

seventy years of age and were growing in an old orchard. In both cases examination of sections from one-year-old, three-year-old, and five-year-old branches revealed the fact that by July 17 the last few layers of xylem cells were being formed, and sometimes between July 23 and July 30 the xylem and phloem formation was completed and the cells were completely differentiated. The cambium was then in its resting condition. Material was also taken from three-year-old and five-year-old branches of the pear. The tree was about twenty years of age and was growing in a yard. In each case xylem formation was completed by July 17. Incidental observations made on the plum, peach, and cherry on three- and four-year-old branches indicated that xylem formation was complete by July 23 and the cambium was in a resting condition. These trees were bearing trees about twenty years old and were growing in a farmyard.

In concluding, mention should be made of the fact that no evidence was obtained to indicate that phloem formation continued later than xylem formation.